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ABSTRACT

The focus of this study is an eight-week science enrichment mentorship program for elementary and middle school girls (ages 8 to 13) at Coleson Village, a public housing community, in an urban area of western Washington. The goal of the program was to build confidence and encourage creativity as the participants discovered themselves as competent participants in science, and to introduce the participants to quality mentors in science who would further encourage growth and confidence in science. Data collection instruments included a "draw a scientist" test, interviews, questionnaires, journals, and ongoing observation. The girls developed science fair projects with their mentors and presented them at a community science fair held at their community center. This study provided insight into how girls prefer to approach learning situations in a cooperative manner, as well as how girls tend to look for relationship between themselves and the content. The enrichment program was successful in helping the girls develop a voice in their study of science. Most girls went from having negative or neutral feelings about science to exchanging stories about the activities and projects in which they engaged in this program, and to building relationships with strong female mentors pursuing science careers. (Contains 48 references.) (Author/ASK)

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BUILDING AND ENCOURAGING CONFIDENCE AND CREATIVITY IN SCIENCE

by
Lynnette J. Ryan

A thesis submitted in partial fulfillment of the
requirements for the degree of
Masters in Teaching

Saint Martin's College
Lacey, Washington
September, 2000

L Ryan

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We are familiar with the idea that a form of mysticism—a commitment to the unity of experience, the oneness of nature—plays an essential role in the process of scientific discovery. Einstein called it 'cosmic religiosity.' In turn, the experience of creative insight reinforces these commitments, fostering a sense of the limitations of the scientific method, and an appreciation of other ways of knowing. (Keller, 1983, p. 201).

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DEDICATION

This work is dedicated to the many women in science who never received proper recognition for their amazing work, and who have gone before us to blaze a trail. And while today the path is easier to travel, it is not without pitfalls, perils and frustrations. May all the young women who pursue science today and in the future remember that we all have a responsibility for maintaining the trail that was so vehemently created, so adamantly fought for, and so diligently traveled.

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Thank you so much to the mentors who donated their time and energy to this project. You were integral to this study—forming warm, caring relationships with the girls and reminding them that science is fun and rewarding.

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ABSTRACT

BUILDING AND ENCOURAGING CONFIDENCE AND CREATIVITY IN SCIENCE

by Lynnette J. Ryan

The focus of this study is an eight-week science enrichment mentorship program for elementary and middle school girls (ages 8 to 13) at Coleson Village, a public housing community, in an urban area of Western Washington. The goal of the program was to build confidence and encourage creativity as the participants discovered themselves as competent participants in science, and to introduce the participants to quality mentors in science who would further encourage growth and confidence in science. Data collection instruments included a 'draw a scientist' test, interviews, questionnaires, journals, and on-going observation. The girls developed science fair projects with their mentors and presented them at a community science fair held at their community center. This study provided insight into how girls prefer to approach learning situations in a cooperative manner, as well as how girls tend to look for relationship between themselves and the content. The enrichment program was successful in helping the girls develop a voice in their study of science. Most girls went from having negative or neutral feelings about science to exchanging stories about the activities and projects in which they engaged in this program, and to building relationships with strong female mentors pursuing science careers.

CHAPTER 1

"When we are done with this program, you may not remember how to make goo, or how to wire a complete circuit so that the light bulb stays on and the buzzer can be turned on and off with a switch, but there some things that I want you to be sure to remember.

Are you all listening?

You are valuable. You are worthwhile. You can do anything you set you mind to. You have an important contribution to make to your community—you are doing that here today. You are beautiful and intelligent young women. You are valuable."

I spoke these words to the girls at Coleson Village (name has been changed) during the awards ceremony at their science fair. It was difficult to finish my speech without crying. I had practiced it many times and teared-up each time. I couldn't help but wonder if I was so moved because they were words that were never spoken to me. Words that would have made such a difference in my life and in how I felt about myself. Girls are often devalued in our society. They need to know that they matter and that their contributions, especially in the area of science, are important to the continuation of

learning. They need to feel free to pursue their interests regardless of the ways in which our society has created its institutions.

This was the premise on which my study was built. Not only am I concerned with the general worth given to females and their roles in our society, but I am also concerned about how females fare in science classrooms. If women are to better their financial position in society and become more self-sufficient, they must begin entering careers that have been primarily dominated by men. Many of these careers are science-related--such as engineering and information technology--and these careers pay higher salaries than many of the jobs women currently fill. This work must begin with young girls in school who are just forming opinions about themselves and visualizing their futures.

Girls and Science

In general, girls "…tend to pursue a narrower set of career opportunities than do boys…In fact, women cluster in only 20 of the more than 400 job categories, and two out of three minimum-wage earners are women. Statistics make it clear that girls still face gender barriers when they prepare to enter the work force." (AAUW, 2000, p. 1). Women are underrepresented in jobs that rely on science and engineering (Pollina, 1995, p. 30; Campbell, 1992, p. 3). This is an important area on which to focus if women are to achieve equality, become independent, economically autonomous, self-reliant, and are to create better lives for themselves and their families.

During my experience as a school volunteer and as a teacher, I have noticed that girls seem to arrive at a point where they lose interest in the sciences. I volunteered in a middle school, in 6th grade and 8th grade science classrooms, to see if there was a noticeable

difference in how girls in these two age groups approached science. The ways in which girls approached labs in these two grade levels were much different. In the 6th grade classroom, girls and boys did lab work together and, for the most part, girls dominated the groups. However, in the 8th grade classrooms girls seemed disinterested. In co-ed groups, they allowed the boys to take charge. In single-sex groups, they did the work, but generally acted a bit confused and in need of help. How can two years make such a difference in girls' approach to science? And what can we as teachers do to maximize girls' engagement in science?

Many researchers have discovered that girls indeed tend to lose interest in science during these critical middle school years (age 11 to 13). "In early adolescence, studies show that girls' IQ scores drop and their math and science scores plummet." (Pipher, 1994, p. 19). Mary Pipher (1994) claims that cultural pressure on girls hits them hard around adolescence. They feel pressure to adopt a 'false self,' a self that is not who they truly are inside, that conforms to societal expectations of what a girl *should* be (p. 37). Along with this comes a lack of interest in things considered 'unladylike.' Science and math fall into this category for many people, for a large proportion of girls and women, and for our culture (Pipher, 1994, p. 37; Coppula, 1997, p. 14). We need to remind girls that science is not just a male pursuit and that they can build competency in this area. One way to begin doing this is to teach science in a way that is conducive to the learning styles of females.

There is some indication that current methods of teaching science do not support ways in which girls like to learn. Traditionally, science methods have focused on inquiry learning, laboratory activities, demonstrations, and lectures. However, these methods do not necessarily match the learning styles of females who generally require more

cooperative learning opportunities than do their male counterparts. Females tend to prefer interpersonal situations in which work is group oriented and during which they can discuss the material with others. In addition, "…females in mixed-sex cooperative groups often revert to a pattern of not interacting with male students, allowing males to dominate them, and viewing themselves as less helpful, less important, and less visible." (Grossman and Grossman, 1994, p. 136). These feelings of inadequacy can take the fun out of learning science and create an atmosphere in the science classroom that is hostile and that pushes females away.

My Own Experiences

My own early science experience was similar to that described by researchers. In my own pursuit of science, I encountered several obstacles. My middle school and high school science teachers were boring, and were not willing to explain concepts more than once. If I did not understand a concept, I was out of luck. My physics teacher became visibly agitated when asked a question. He would say things like, "If you don't know that by now, you should get out of this class." I felt isolated and inferior. His relationship with the male students was much more congenial. The boys seemed to fit into the classroom culture better than the girls.

I had no role models or mentors in science and never thought that I would pursue a career that had anything to do with science. In my twenties, I worked as a receptionist at an air separation plant. I became friends with the plant engineer who had majored in chemical engineering in college. He did not treat me like I was inferior; rather he delighted in answering my questions and sharing information with me about how the plant worked. I

was fascinated. I began night school to pursue a degree in chemical engineering. However, in my first year at a community college, when I took calculus, I again felt defeated and 'dumb.' I was getting a "C" in my calculus course and had never before gotten a grade that low. When I talked to the instructor about my concern, he replied, "You should be happy with the grade you have. It's a good grade for a woman in this course." Again, isolation and a feeling of inferiority took over. I dropped math after that course, although I found some success in other science courses at the same school. I continued to take courses such as astronomy and geology, which I truly enjoyed.

After giving my future much thought, I decided that while I loved science, I did not want a job like plant engineer at an air separation plant. Rather, I wanted a career in science that would also enable me to give back to the community. I stumbled upon the idea of teaching science and loved the prospect immediately. I was on my way.

As I began to design this study for my Master's thesis, I considered my own past experiences, which became the framework for my research questions. Although I never found a female mentor in science, I worked my way through college, majoring in biology. I then wanted to figure out a way to help encourage girls in the area of science, since my experience had been one of constant and isolated struggle. I decided that by running a science enrichment program in which girls could experience science at their own pace, with support from other women, in a non-competitive environment, I could have an impact on the ways in which girls view themselves in science—in the classroom and in their future careers.

My Thesis Study

My own experiences, as well as everything I had learned about females in science up to this point, played a role in the design of a my thesis study project—a science enrichment program. The program, called *Building and Encouraging Confidence and Creativity in Science* (BECCS), is an 8-week science enrichment program facilitated under the umbrella of Operation S.M.A.R.T. (science, math, and relevant technology) through the YWCA of Tacoma-Pierce County. This project is a case study bound in time and place, about a science enrichment program and the effects it had on the participants, the mentors, and myself. The purpose of the case study was to discover the factors involved in girls' level of confidence in science and to determine whether or not a science enrichment activity, including contact with quality female role models, would increase their confidence level and/or increase creativity in the ways they approach science activities.

The program began on Saturday, March 11, 2000 with a kick-off gathering. Beginning, Tuesday, March 14, 2000, we met at the Coleson Village Commons Building from 5:00pm to 6:30 pm every Tuesday evening. We ended the program with a community science fair on Saturday, April 6, 2000. The program catered to twelve girls, ages 8 to 13, seven of whom attended on a regular basis. Seven mentors worked with the girls on a regular basis.

The YWCA of Tacoma-Pierce County graciously allowed me to pursue my study under the umbrella of Operation S.M.A.R.T. (Science, Math, And Relevant Technology.), an informal educational science program developed and trademarked by Girls Incorporated. The YWCA sponsors these programs in several schools and communities

and has adapted it to best suit the needs of the community. I conducted my program at Coleson Village, a public housing community in an urban area.

As I designed this study, there were several questions that I wanted to answer. Why do girls lose interest in science in middle school? Are there teaching methods that would help engage girls? Besides teaching methods, are there things teachers can do to help girls become engaged in course material? Do science-focused extra-curricular activities and enrichment programs help build girls' confidence in science? Does single-sex grouping enhance girls' participation in science? Does contact with a female role model encourage girls to pursue science in school and in their futures?

Definitions and Delimitations

There are several definitions of which the reader should be aware. The girls who took part in the research study will be referred to as 'girls' and 'participants.' The young women who acted as mentors to the participants will be referred to as 'mentors.' The participants and the mentors all acted as resources for information regarding how girls become interested and stay interested in science. The program was run under the umbrella of Operation S.M.A.R.T., but will be referred to as BECCS, since it was a program designed specifically to answer my thesis questions. In addition to BECCS data collection instruments, two Operation S.M.A.R.T. survey forms created by the YWCA of Tacoma-Pierce County were used in data collection and they will be referred to as such.

An important delimitation to consider in my study is the fact that different people perceive situations differently. Many questions that were asked of the girls and mentors are based on individual perceptions of the problem. For example, I perceived discrimination in my high school science classroom and felt male students received preferential treatment. Not all students may have perceived the class in that way. There are many factors that interact to create an individual's perception, not the least of which is their self-concept. In this study, there were only two mentors who reported feeling any sort of sex discrimination in their own pursuit of science. This could be because the rest of the mentors truly did not encounter any obstacles, but it could also be that they were not aware of it, because of their ages or education backgrounds, or because the environment in which they experienced it minimized its existence.

Also, the participants and mentors displayed varying degrees of awareness of the ways in which the women around them participate in science. Some of the mentors never realized that so many of the women in their college science department were biology majors, and that hardly any of them were physics and chemistry majors. Their levels of awareness, however, made my findings more interesting and important, since many of them were actually enlightened by their experiences in this program.

CHAPTER 2

The fact that most gender bias takes place in subtle messages makes it more potent, not less. Open bigotry is recognizable and outrageous, so it is easier to resist. The very subtlety of 'modern' gender bias means we are not consciously aware of it. Girls and women internalize gender bias, as do we all, and it looks for all the world like girls and women are simply exercising their free choice to take up literature, art, French, history, and indeed, education. It can even look like girls and women are 'naturally' untalented in math or science. (Sanders, 2000, p. 28).

There is a great deal of material written about women in science—how and why this gender gap exists between males and females in the areas of math, science, and technology. Fewer books and articles are written about ways in which we can change our approach in order to enable girls and women to find more success in science. Still fewer writings exist about how and why enrichment programs help encourage girls in science, if, in fact, they do. The goal was to find out whether or not science enrichment programs work, and how they work to encourage girls to pursue science.

The research base reveals ideas about how women participate in science currently, how prior experience has been shown to play a role in females' level of confidence in science, the general ways in which females prefer to learn, and how females generally view themselves in relationship to science. The information uncovered in the research base

framed the science enrichment program design and supported the idea for participants to work together to solve problems in a non-competitive, safe environment. An environment in which mentors would be brimming with encouragement and enthusiasm, and in which participants would feel empowered in the area of science.

Nature of Science

"Science and math are hard disciplines that are perceived by girls as cold, isolating masculine pursuits that are pointless and unrewarding for them." (Mann, 1994, p. 2).

In our culture, science has historically been associated with masculinity (Schiebinger, 1987, p. 33; Mann, 1994, p. 2). Many studies have supported this association. One study that used the draw-a-scientist test and conducted follow-up interviews found that both males and females view science, in a stereotypical sense, as a male domain (Mason, Kahle, and Gardner, 1991). Likewise, a study conducted by Kahle and Meece (1994) found that on a masculine-feminine scale, both men and women rated science courses as masculine (p. 543).

The idea that science is a masculine pursuit makes sense when we look at the history of science. According to Schiebinger (1987), women have been left out of the history of science, even though they have been involved at least since 1830 Germany (p. 7). From early in history, women have been involved in all areas of science—physics, chemistry, medicine, mathematics, astronomy—yet we continue to find fewer women than men in science (Schiebinger, 1987, p. 8). Even though women have been involved in science, their contributions are often left out of history and science books. Women who are

mentioned as having made contributions to 'mainstream' science are considered 'exceptional. They are the "…women who defied convention to claim a prominent position in an essentially male world." (Schiebinger, 1987, p. 16).

Some researchers claim that because science has been primarily a male pursuit, and because we have focused on male contributions to the research base of science, that the norms and methods of scientific practice may be distorted. Keller (1987) agrees that the "…truth and necessity of the conclusions of natural sciences…reflect the judgment of men." (p. 236), and that we need to begin look at ways to integrate empirical scientific practice with 'critical self-reflection.' (Keller, 1987, p. 238).

Women indeed may not choose to pursue science because they are not intrigued by the 'truth' with which modern science often concerns itself. Schiebinger (1987) theorizes that women are not necessarily drawn to science as a life-long pursuit because of the dangers of modern science, especially its military connections and the negative impact on the environment which often occurs during 'scientific pursuits. "…it is not enough for women to be scientists if science is to proceed along its present course; the task of opening science to women must be combined with the task of making science more responsible." (p. 9).

In addition, women may not be drawn to pursue science because it is generally viewed as a competitive endeavor. Shepherd (1993) claims that "competition drives much of science in the United States from the top down." (p. 183). Basic research and science are funded and supported in order to compete in national and international markets. In today's highly technological world, science plays a major role in our ongoing competitiveness (Shepherd, 1993, p. 184). Competition is not conducive to the ways in

which females typically prefer to learn and work, which may be one reason why fewer females than males pursue science.

Schiebinger (1987) reminds us of the importance of keeping the male perspective in science while honoring the female perspective. "The feminist critique of science promotes feminine values as an essential aspect of human experience and envisions a science that would integrate all aspects of human experience into our understanding of the natural world....The task of making science less masculine is also the task of making it more completely human." (p. 34). Indeed, if we are to bring more females into science, we may need to change the ways in which we have traditionally viewed and practiced science.

Women in Science and Society

"Women have been more systematically excluded from doing serious science than from performing any other social activity, except, perhaps, frontline warfare." (Harding, 1986, p. 31).

Current research shows that females do not choose science courses and careers as often as males. There has been a great deal of research regarding the gender gap in school science achievement. While current data suggest that there is a narrowing of gender differences in achievement in various areas, "...a narrowing of differences is not an absence of differences." (American Association of University Women, 1992, p. 34). In general, there is little difference between the numbers of science courses that boys and girls take, but the gap in science achievement may be increasing. According to the National

Assessment of Education Progress (NAEP), between the years of 1978 and 1986, female performance in science remained the same while male performance increased (AAUW, 1992, p. 42). In addition, girls take biology as often as their male counterparts, but boys are more inclined to enroll in physics and advanced chemistry. Boys are also more inclined to pursue science careers upon leaving secondary school (AAUW, 1998; National Center for Education Statistics, 1998). Why do these differences exist?

Mahood (1994) claims that there are three main reasons why females often do not choose science. First, some girls have a difficult time with visual-spatial abilities and thus do not do well in math and science. Second, socialization plays a key role in keeping young women out of science careers. Finally, young women do not choose science as a career because there is a lack of female role models—"…girls don't choose science because it simply doesn't occur to them." (Mahood, 1994, p. 20).

Other researchers add support to the idea that society plays a role in keeping young women from choosing science. Studies have shown that girls begin to lose interest in science during their middle school years. "At this age, …girls begin to become more sensitive to how others perceive them and are vulnerable to cues from teachers, parents, and schoolmates—as well as from television characters and toys—that suggest engineering and science are not 'feminine.'" (Coppula, 1997, p. 14).

Many claim that it is the ways in which we socialize boys and girls that takes away the female voice—that the nature of our culture requires girls to submit to others' ideas and take a lesser role in creating truth (Pipher, 1994, p. 37; Schwartz and Hanson, 1992; Lynem, 1998). "Adolescent girls experience a conflict between their autonomous selves and their need to be feminine." (Pipher, 1994, p. 21).

This point is especially interesting when we look at a brief history of how women entered the area of science in academia.

> The increase in numbers by 1940 was the result of a century of heroic struggle. Through a variety of strategies the women's colleges were founded and began to offer science education to women. But the official justification for educating women was not that they could then obtain opportunities equal to those available to educated men,…rather, the public justification for women's colleges was that educated women could raise better sons…,thus the opportunities available to educated women would be limited by familiar culturally created gender stereotypes. (Harding, 1986, p. 60).

When asked what the most significant barriers to women's success in science are, Rita Colwell, director of the National Science Foundation, replied,

> It's a bit of a bore to have to go to class day after day after day, and, when you put your hand up, to be ignored. Or, if you should—heaven forbid—make a slight mistake, to be ridiculed in a way that your male colleagues are not. It's such a bore, when you have to assert yourself to constantly perform harder, better, longer. You're human, you get sort of tired of it. So if you don't have this really powerful drive to prove folks wrong and really succeed, you may say, look, what's the point? And drop out. That's where it's important to have mentors and support groups and the kind of psychological assurance that you're OK, you're fine, it's those guys who are wrong, not you. And if you don't have that reassurance, you break down

and move over to some place where you'll be happier and more comfortable. (Gray, 2000, p. 8).

Prior Experience

"If the science in my class is dependent upon the out-of-class experiences of the children, it favors the boys over the girls." (Osborne, 1997, p. 11).

One of the main gaps between male and female science students seems to be prior experience. Generally, prior experience refers to practice outside the classroom—at home, during play, or in extra-curricular activities—which give a student prior knowledge about concepts. With science, we generally think of prior experience as activity that occurs on a regular basis, in an atmosphere of exploration, where there are few limits and time to test hypotheses.

"A national study of science education (National Assessment of Education Progress, 1990) found a clear discrepancy between boys' and girls' hands-on experience of common science equipment, especially in the area of electrical equipment." (Sanders, 2000, p. 24). Males tend to have more prior experience with science concepts and hands-on 'experiments' than do females (Farenga and Joyce, 1997, p. 565). The differences between science-related experiences for boys and girls must be addressed or the inequities in education will remain.

Many studies have claimed that a lack of prior experience can cause girls to doubt their abilities which leads to decreased interest and dropping out of the academic subject (Farenga and Joyce, 1997, p. 566; Brown, Slater, and Adams, 1998, p. 527). If girls doubt

their abilities and do not perform well in science, learning is not enjoyable and girls choose to pursue other subjects. This, in turn, increases their distance from science-related activities and prior experience is compromised even more. Enrichment programs may be the key for encouraging girls in the areas of math, science and technology. These programs help them attain valuable science experience and 'catch up' with their male counterparts; The girls are allowed to play with science at their own pace, outside of the often competitive environment of the classroom.

Campbell and Clewell (1999) tell us that there is a general 'lack of engagement' in math and science that greatly affects girls. This is because "…they are less likely than boys to get involved in science and math activities outside of school, from using meters and playing with electromagnets to fixing things and reading about technology." (p. 3). Boys are more often encouraged, and may actually seek out the opportunities, to help Dad fix the lawn mower or the kitchen sink, while girls are less likely to be asked to participate in these activities.

One teacher writes,

> In our society, it is usually boys who have more and richer 'science' experiences in their everyday life—they make messes with mud and frogs and insects, they play games which illustrate the basic laws of physics, they work with tools and machines and the simple experimental methods involved in home construction, fix-it projects, machine maintenance. In a simplistic sense, boys' worlds mimic men's' worlds which mimic the worlds of conventional science, and this puts their experiences in a privileged position. (Osborne, 1997, p. 11).

How Females Prefer to Learn

"Educational strategies that take into account girls' core values of sharing and cooperation, as well as their need for close relationship with other girls, will produce an...environment that is more supportive of girls." (Mann, 1994, p. 4).

A great deal of research has identified and confirmed the ways in which females typically prefer to learn and receive information. Learning style is generally defined by personality and methods of social interaction. For females, a common method of social interaction is discussion and relationship building. It makes sense, then, that females tend to prefer interactive modes of learning, such as cooperative learning, discussion, and hands-on, group activities. Female students often require more cooperative learning opportunities than do their male counterparts because they prefer interpersonal situations in which work is group oriented and during which they can discuss the material with others (Grossman and Grossman, 1994).

Furthermore, females have been found to react differently in same-sex and mixed-sex group. In all female groups, females express agreement with one another, pause to give another person a chance to speak, and will acknowledge what someone else says before beginning to speak (Maccoby, 1988, p. 761; Sewartz and Hanson, 1992; Mann, 1994, p. 2; Philbin, Meier, Huffman, and Boverie, 1995, p. 485; Erickson and Erickson, 1984). Some studies show that females actually learn more in same-sex cooperative groups than in mixed-gender groups. Grossman and Grossman (1994) claim that "...females in mixed-sex cooperative groups often revert to a pattern of not interacting with male students,

allowing males to dominate them, and viewing themselves a less helpful, less important, and less visible." (p. 136).

The Female Brain

Many researchers have focused their studies on gender differences in how the brain functions. They have concerned themselves with the male and female brain, and whether or not they are significantly different. If they are, this could be one reason that males and females have different modes and preferred methods of learning, and why males and females appear to have different aptitudes for diverse tasks.

One area of study has focused on sex differences in brain asymmetry, and whether or not males and females exhibit hemispheric specialization and dominance, a condition in which "…one half of the brain is more or less specialized or proficient in its ability to process certain types of stimuli." (McWhinnie, 1997, p. 4)

Many studies have attempted to show cerebral lateralization in males and females. The Society for Neuroscience (1998) discusses research which demonstrated that a group of males and females performed equally well on verbal tests, but imaging results showed females using areas on both the right and left sides of the brain and males using areas on just the left side of the brain (p. 2). Levy-Argestic (1980) found something similar—that females may use both hemispheres when solving spatial tasks. Still other studies have shown that males tend to use the right side of the brain more and that females tend to use the left side more. In another study, Gallusico, Evermann, and Gagnon (1987) found that males showed a 'left cerebra' dominance (p. 609). The contradiction in the research base clearly shows a need for more study in this area.

In her article entitled *Sex Differences and the Dichotomization of the Brain*, Susan Leigh Star (1979) discusses past and current research on brain asymmetry in males and females. She claims that many past studies are only supported by assumptions based on observations, not data obtained from physiological tests (p. 119). Likewise, McWhinnie (1997) discusses the fact that studies which show that one side of the brain will compensate for the other side when function is lost through trauma makes 'theories of separation of cerebral function' not so clear as first thought (p. 5). McWhinnie (1997) goes on to say, "It would seem that while the initial set to respond is controled [sic] by hemispheric preferences, very quickly both hemispheres are involved in most cerebral tasks." (p. 5).

Another major area of study in male and female brain research concerns itself with the size of the corpus callosum. Monroe (1995) claims "…the corpus callosum, the nerve cable that connects the right and left parts of the brain, is thicker in women." (p. 22). This finding is supported by other studies. DeLacoste-Utamsing and Holloway (1982), found that the posterior portion of the corpus callosum is more 'bulbous' and larger in females than in males (p. 1431). DeLacoste-Utamsing and Holloway (1982) claim that this may be "…an anatomical basis for possible gender differences in the degree of cerebral lateralization." (p. 1431). Likewise, Johnson, Farnworth, Pinkston, Bigler, and Blatter (1994) also found that "…females have significantly larger corpus callosum relative to total intracranial volume." (p. 376). But what does this mean in terms of learning? Research has yet to answer this important question.

Although there seems to be adequate support to suggest differences in the male and female brain, we can only speculate on the functional significance of these differences. The presence of these differences is not to say that one condition is good or bad, or that one

gender is smarter than another. And, as Susan Leigh Star (1979) cautions, we must remember that "…research on sex differences takes place within a gender-stratified society. That is, we are born into a sexual caste system and are heavily indoctrinated from birth with its values" (p. 115). We have no way to determine whether the differences are 'innate' (nature) or environmental (nurture) and how these differences may affect the outcome. However, research may provide some idea about the differences that might exists between the sexes and that need to be addressed in our teaching methodologies.

Traditional Methods of Teaching Science

There is some evidence that current methods of teaching science in school are not necessarily conducive to the methods by which females prefer to learn. In their report, How School Shortchange Girls (1995), the AAUW claims that "few classrooms foster 'connected learning' nor are the majority of classrooms designed to encourage cooperative behaviors and collaborative approaches." (p. 125).

Traditionally, science teachers have employed teaching methods that include inquiry learning, laboratory work, demonstrations, and lecture (Farmer and Farrell, 1980, p. 5; Collette and Chiappetta, 1986, p. 46; Duschl, 1990, p. 101; National Research Council, 1997, p. 9), since their training has taught them that these are the methods best suited to science instruction. In a 1994 study, Tobin, Tippins, and Gallard found that traditional science classrooms emphasized learning how to use procedures and computational efficiency by using type examples, algorithms, and rules of thumb to learn in a procedural manner (p. 49). "Research studies reveal a tendency beginning at the preschool level for schools to choose classroom activities that will appeal to boys' interests and to select

presentation formats in which boys excel or are encouraged more than are girls." (AAUW, 1992, p. 123).

These methods of science instruction are often contradictory to the ways in which females prefer to learn. Inquiry learning, used often in science classrooms as a teacher-directed activity, requires the student to process information quickly and ask questions. This requires some risk-taking behavior because the student must be willing to ask a questions and/or formulate a theory, which may be wrong, in front of his/her peers. Depending on how the instructor handles the question and answer session, girls may be afraid to venture a 'guess' about the phenomenon. There is also an element of competition in this type of question and answer inquiry. The assumption is whoever asks the right questions and figures out the problem is the smartest. Since females prefer cooperative work, these science instructional methods may not provide an optimum learning environment for girls.

Demonstrations are similar to inquiry sessions. Students process information independently, and to get maximum information from the demonstration, students must ask and answer questions in a large group. Again, risk-taking and competitive situations are not comfortable for most females.

Straight lecture, without discussion or interaction, seems to be incongruent with girls' preferred modes of learning as well. Lecture is very independent. While students are generally expected to take notes, there is no active or cooperative environment in which the concepts are reviewed, at least not during the lecture.

Finally, lab work may be one are where girls can excel in science since it is cooperative in nature. However, since co-ed lab groups are common in most science

classes, boys will often take the lead (since they have more prior experience) and girls will typically let them, especially if they have any doubt about their own abilities in science (Grossman and Grossman, 1994, p. 140). Unfortunately, many science teachers choose to offer a minimum of lab activities compared to inquiry, demonstration and lecture due to classroom management concerns, budget issues, and time constraints.

These traditional science methods, if used in conventional ways, do not fit girls' learning styles. Girls feel out of place in the traditional science classroom. The emphasis on competition and risk-taking behavior causes girls to separate themselves from the science curriculum. If they cannot find a connection to their own lives, and cannot relate to the methods of scientific inquiry, how can they become engaged in science?

In addition to methods used to teach science, teacher mannerism may also be a factor in pushing women away from or attracting more women to science. Belenky, et. al. (1986) claim that "...it is especially critical that teachers of science do all that they can do to avoid the appearance of omniscience. Between the scientific expert and the layman, says the feminist scholar, Elizabeth Fee, there is rarely any dialogue." (p. 216). It appears to be very important to the learning process that teachers demonstrate the process of discovery and self-directed inquiry, rather than merely present facts to be learned. Enrichment programs provide an environment in which the teacher/facilitator is able to work with young women on a level that is often unattainable in a large classroom. Educators are more likely to show their own thought processes when working through problems and activities in an informal setting.

Single-Gender Education

Single-gender education has been shown by many researchers to be a positive experience, especially for girls. Many schools have responded to research that claims that girls achieve more in environments in which they feel empowered, and have begun offering single-gender classes in which girls and boys are taught in separate classes (Pollina, 1995, p. 34).

Many times classroom curriculum and teacher interactions are driven by the needs of the male students in class (AAUW, 1992, p. 118). Pipher (1994) tells us that

> boys are twice as likely to be seen as role models, five times as likely to receive teachers' attention and twelve times as likely to speak up in class. Teachers chose many more classroom activities that appeal to boys than to girls. Girls are exposed to almost three times as many boy-centered stories as girl-centered stories. Boys tend to be portrayed as clever, brave, creative and resourceful, while girls are depicted as kind, dependent and docile. Girls read six times as many biographies of males as of females. (p. 62).

These are difficult odds to overcome as female students make an effort to preserve self-confidence and self-worth, and find connection with class content to their individual lives.

As discussed previously, teaching methods, especially in science, favor boys' modes of learning (AAUW, 1992, p. 123). Even when cooperative learning activities are offered in the co-ed classroom, boys often end up leading the groups and the girls take a backseat role.

> Some research indicates that the infrequent use of small, unstructured work groups is not effective in reducing gender stereotypes, and, in fact, increases

> stereotyping. Groups often provide boys with leadership opportunities that increase their self-esteem. Females are often seen as followers and are less likely to want to work in mixed-sex groups in the future. (AAUW, 1992, p. 127).

Girls often lack the confidence to tolerate the frustration that occurs when problem solving in math and science. Girls tend to think that they are stupid and cannot solve the problem, so they give up (Pipher, 1994, p. 63). Coupled with a co-ed learning environment in which boys are likely to stay with the problem even though it may be difficult, and little or no support for the female learning style, it is no wonder that girls often lose interest in subjects like math and science. "Girls need to be encouraged to persevere in the face of difficulty, to calm down and believe in themselves. They need permission to take their time and to make many mistakes before solving the problem." (Pipher, 1994, p. 63).

Researchers argue that pedagogy and practices of the teacher make a big difference in the experience that students have in single-gender and co-ed learning environments (Campbell and Wahl, 1998, p. 63), and that separation is not a long-term solution to the gender-gap in science (AAUW, 1998, p. 46). However, in a single-gender learning environment, the methods and teaching styles can be adapted to better fit girls' learning styles and empower them to explore at their own pace, working cooperatively with other girls. As educators, we have something valuable to be learned from our female students about ways in which they learn best, and how changing our methods can positively impact our teaching methods for all students.

Women's Ways of Knowing Science

> *In order to keep their true selves and grow into healthy adults, girls need love from family and friends, meaningful work, respect, challenges and physical and psychological safety. They need identities based on talents or interests rather than appearance, popularity or sexuality.... They need to feel that they are part of something larger than their own lives and that they are emotionally connected to a whole. (Pipher, 1994, p. 283).*

Research has told us that women prefer interactive relationships in which they can form some type of connection. It makes sense that this desire transfers to education and learning. Research has shown that the number of women who major in science is on the increase, but that women tend to major more in life sciences, than sciences such as physics, chemistry, and/or math (AAUW, 1992, p. 43; Erickson and Erickson, 1984, p. 65). Why? One idea is that women can 'relate' more to the content in a biology course, since the content generally focuses on living organisms around us, and for which women tend to have adequate prior experience. Sandra Harding (1986), in her discussion about gender and science, proposes, "...the concern in biology, anthropology, and psychology with interactive relationships between organisms, and between organisms and environments, may reflect a specifically feminine way of conceptualizing very abstract relationships." (p. 32).

There may be some clues about why women seek relationship content and method in the ideas proposed in *Women's Ways of Knowing: The Development of Self, Voice, and Mind*, a book written by Belenky, Clinchy, Goldberger, and Tarule. Belenky, et. al. (1986)

claim that there are five different ways in which women interact with the information presented to them, depending on their age, their life experiences, and their education. In the first stage, *silence*, women have no capacity for representational thought. In the second stage, *received knowledge*, women's opinions are received from others and are dualistic in nature. Likewise, in the third stage, *subjective knowledge*, women's views and opinions are dualist, but they are constructed from within themselves rather than from others.

Often, academic experience and exposure to diversity of opinion are the agents that move women into the fourth stage of knowing, *procedural knowledge*. "...the catalyst for the move is the simple and profound discovery that there is a diversity of opinion about what is good and what is right." (Belenky, et. al., 1986, p. 62). According to Belenky, et. al. (1986), in the procedural knowledge stage, women develop a 'humbler, but more powerful' voice (p. 94). Women are often quiet in this stage but, unlike the *silence* way of knowing, women are processing and thinking about what they will say when they do speak. Procedural knowledge is usually experienced as *separate*, in which critical thinking focuses thought, or *connected*, in which knowledge and learning is based on personal experience and empathy. The final stage of women's thought is *constructed knowledge*. In this stage, women seek to integrate intuitive thoughts and knowledge with the important pieces that they learn from others. "Rather than extricating the self in the acquisition of knowledge, these women use themselves in rising to a new way of thinking." (Belenky, et. al, 1986, p. 135).

According to Belenky, et. al., (1986) women progress from one stage of knowing to the next, with separate knowing being the beginning and constructed knowledge being the destination, and even move between the ways of knowing as they search for themselves

and a voice (p. 133). If these stages are accurate for most women, it makes sense then that women look for connection and relationship in their endeavors, including education and science. Women may indeed require a different approach to teaching and learning science than men require. Belenky, et. al., (1986) conclude that for many girls and women, optimum learning takes place in an environment in which they are allowed to approach the subject with empathy, or *connected knowing*.

In her book, *Lifting the Veil: The Feminine Face of Science*, Linda Jean Shepherd compares women's ways of knowing with men's forms of intellectual and ethical development as outlined by William Perry. In Perry's research, he found that men move from *basic dualism* to *multiplicity* to *relativism subordinate* and, finally, to *full relativism* in which knowledge is contextual. Shepherd (1993) noticed that "...both men and women reach a final stage where they realize that knowledge is constructed, contextual, and mutable. But, in contrast to men's ways of knowing, the women's ways are rooted in connection." (p. 39).

But how do these stages relate to women in science? An interesting finding made by Belenky, et. al. (1986) was that rejection of science was common among subjective knowers. Many of these women spoke of their distrust of science and their feelings of alienation from the content (p. 71). The authors point out that there has been a great deal of debate over the issues of how science relates to women, specifically "...the equation of the masculine with objectivity, science, and the scientific method in its emphasis on manipulation, control, and distance from the objects of study." (Belenky, et. al., 1986, p. 72).

Barr and Birke (1994) found something similar—that science seems abstract to many women and unrelated to their lives. They talk about 'science for specific social purposes,' in which women seek scientific information as it relates to their personal needs and experiences (p. 474). In their research, Barr and Birke (1994) found two common ways in which women view science.

> One is that, when they label knowledge as scientific, it usually means something they do not understand: What they understand by contrast, is likely to be labeled common sense. The second tension can be summed up in the aphorism: 'Science is in everything, but it has nothing to do with me.' This may be because science has traditionally been viewed as primarily a male pursuit, concerned with problems important to men. Taken together, these themes serve as a stark reminder of the extent of women's exclusion from scientific knowledge. (p. 475).

Women are often alienated from science because they experience it as a set of facts to be learned, rather than as a process of discovery. This can be especially detrimental to women in science because there is evidence that they want to see connections and relationships in the content. "Barbara McClintock won her Nobel Prize because she developed a way of working, a way of asking questions and understanding, that differed from traditionally male definitions of scientific objectivity." (Sanders, 2000, p. 26). According to Keller (1983), Barbara McClintock developed a 'feeling for the organism' that drove her study question development in genetics (p. 198).

In addition, Pollina (1995) points out that Jane Goodall and Dian Fossey took a 'relational approach' to their work and focused on just one ape for their studies. They

abandoned the traditional methods of hypothesizing and corroborating data by observing a group of apes (p. 31). These women took an important step of bringing emotion and relationship into their studies.

Summary

"To learn to speak in a unique and authentic voice, women must 'jump outside' the frames and systems authorities provide and create their own frame." (Belenky, et. al, 1986, p. 134).

The research base reveals important information about how women prefer to approach science and how this differs from the traditional approach to science. In general, females choose science courses and careers less often than their male counterparts. This may be why society typically views science as a masculine pursuit that is concerned with issues that are important primarily to men. The fact that boys tend to have more extensive prior experience with science concepts than girls, coupled with the notion that girls' preferred methods of learning are not necessarily supported by the traditional methods by which science is taught, may put females at a significant disadvantage in the science classroom. Finally, because females tend to look for connection and relationship between their own lives and the curriculum, their rejection of science may be related to a lack of meaningful connection between themselves and science concepts. This is important information to consider as we look at ways to change how females view science.

One way to give girls a chance to see themselves doing science, discuss and enjoy science on their own terms, and talk about their own connections to science in a meaningful

way, is to give them the opportunity to participate in a science enrichment program. They are given a chance to develop prior experience that is so important in a science class and in building confidence in the area of science. In addition, they have a chance to 'know' science in a way that makes sense for them. They have an opportunity to find ways in which their own experiences are relevant to science, and have a relationship to others' experiences. Girls begin to develop a sense of self in relationship to the subject matter. When this happens, girls will choose to learn science and continue the path to creating meaning between their lives and the content.

CHAPTER 3

As I thought about my past experiences in science education and the important lessons to be learned from the research base, I began to develop my thesis study. Qualitative research was chosen since it often involves the telling of a story, not just weaving a tale that is interesting to read and has a beginning, a climax, and an ending, but one that is enlightening in some way. One that uses collected data to support and illuminate a particular experience, phenomenon, life, social interaction, or event. The story I wanted to tell was the story of a group of girls and young women—how they experience science, how they form their opinions about science, and how their perceptions about science can be changed to encourage further study. It seemed best to undertake this study in an environment in which I could work closely with the girls on science-related activities, integrating discussion as we worked. Thus, I chose to design a science enrichment and mentorship program for girls.

Out-of-school, all-girl science enrichment programs are important for many reasons. They tend to be fun and girls like them because they are different than school. There are more hands-on activities and projects and there is less concern with memorizing the facts. Probably most important is the fact that these programs, because they are all girls, tend to be non-competitive with a focus on cooperative learning (Campbell, 1992, p. 4; AAAS, 1993, p. 412). They allow girls a chance to practice important 'prior experience' skills in a safe environment. Girls are able to talk about their own connection to science in a meaningful way, as well as discuss scientific phenomenon on their own terms, before they return to practice it in the co-ed classroom.

As I designed my thesis study, there were several questions that I wanted to answer. What could help girls maintain an interest in science as they enter their middle school years? Are there teaching methods that would better engage girls? Do science-focused extra-curricular activities and enrichment programs help girls gain confidence and creativity in science? Does contact with a female role model or mentor encourage girls to pursue science in school and possibly in their futures?

Enrichment Program Design

Initially, my design for the science enrichment program included activities in math, science, and technology. It was an 8-week program, which involved female mentors who work in science-related careers and would correspond with the participants via e-mail to work out problems or questions that the girls had about the science activities in which they were engaged on a weekly basis. It quickly became too huge—time-consuming and costly. When I proposed my research to the local school district, they told me that if I wanted to run my program in the school, it would need to include boys as well. I had some thinking to do, not only about program design, but also about *why* I was creating the program the way I was.

It took some consideration before I realized that to include boys in my study would compromise the meaning of what I was trying to discover. My very premise was based on the fact that girls learn science differently than boys, and respond to science differently when boys are present. One researcher claimed that girls who participated in a co-ed science enrichment program were actually less interested in science at the end of the program than at the beginning (Campbell, 1992, p. 8). I also realized that many school

districts, like the one to which I initially applied, may still be in a state of denial over the problem that exists for women in science, and may not be in a position to make the necessary changes to help girls find success in science. I knew that I wanted to do my program with an all-female group and that what I was trying to accomplish might need to start at a grassroots level. So, I began to look for community support.

I recalled the summer that I volunteered for Operation S.M.A.R.T. (science, math, and relevant technology) at the YWCA and loved it. It was for girls only and was held at the YWCA facility. It was a program similar in design to the one I had conceived (without the technology piece). I called the YWCA and talked to the director of youth programs. She was interested in my program and asked me to come and meet with her. During our meeting, I was tentative about how much to ask for, but she was open and willing to let me do my project with the YWCA, on my own terms. She offered me a chance to work at a local public housing community, Coleson Village, with a group of young girls, ages 8 to 13, some of whom were first generation immigrants from Moldova, and all of whom lived in the public housing community. Some of the girls had been exposed to Operation S.M.A.R.T. previously, so this would need to be taken into account, but overall they sounded like a wonderful group of young women in need of some extra attention. I was immediately grateful and excited about the prospect of actually getting to work with girls in an enrichment program of my own design.

Because the YWCA is a non-profit organization, my program needed to be simplified to match the available resources. The technology piece of my original design was taken out and the program began to fall into place. The curriculum was designed based on several excellent sources. Using *Investigating Solids, Liquids, and Gases with*

Toys (Sarquis, Hogue, Sarquis, and Woodward, 1997) and *Teaching Physics with Toys* (Taylor, Poth, and Portman, 1995) as resources, as well as some material from Operation S.M.A.R.T., the program became one focused on electricity and states of matter. Weekly agendas and copies of reference materials are located in Appendix A (reprinted with permission). Finally, BECCS became a more feasible project—one that I could realistically undertake. I was again reminded of how things happen for certain reasons, and I was glad that the school district had turned down my research proposal. If they hadn't, I would not have gone to the YWCA and been fortunate enough to work with such enthusiastic supporters to affect change for women in science. Within a couple of weeks, I had worked out the dates and the curriculum and I was ready to meet with the family support coordinator at Coleson Village.

Location

While waiting for the first meeting, I took note of my surroundings at Coleson Village. I recalled that upon driving up the steep paved driveway, I had entered the main housing area where beautiful new houses lined the street. There were small one-family ramblers, large one-family, two-story houses, and enormous duplexes. The houses were painted in wonderful tones that reeked of Martha Stewart—linen and timberwolf colored houses with trim painted in hues that might be called oxblood red, robin egg blue, asparagus green, and wisteria. Each home had a neatly landscaped yard with green grass and small flowers blooming in beds. The backyards were equally neat and attractive. Garbage was in its place, clotheslines were perfectly equipped with clothespins, and storage sheds matched their corresponding homes perfectly, in architecture and color. The homes

spun around to form a near perfect circle, in the center of which was the commons building, playground equipment and a large walking trail. Near the commons building where the science program would be held, was a small, silver box that housed each tenant's mailbox.

I hadn't known what to expect of Coleson Village. "It is a public housing community," and "We have had a recent influx of Russian immigrants" were the only two statements I had heard about this community before visiting there. We all have expectations and preconceived notions about what a public housing community should look like. Modern movie images have taught us that there should be run-down buildings, graffiti, garbage out of its can, dirty minority children running in the streets, and adults smoking their cigarettes like nothing else exists in the world. Public housing communities are dangerous places, places in which the poor in our society waste the days away waiting for the next welfare check. However, these stereotypes did not describe Coleson Village. Coleson Village was beautiful and well kept, and the families and children were wonderful.

As I sat waiting for my meeting, I also took in the many wonderful pictures of the people who live at Coleson Village. An elderly man strolling on the walking trail, and a mother of three young children, characteristically tired like other mothers I know. Both adults anxious to get the mail that awaited them in their mailboxes. Many children were arriving from school, happy to be home, smiling, racing to get to the door where they could drop their heavy backpacks. There was a group of older middle-school girls in one of the backyards. They were flirting with the one boy who was there. Dancing, turning cartwheels, loud laughter, and hair flipping were the norm in this group of young women. Each girl seemed to be trying anything that might attract the attention of the boy.

Eventually the girls went into the house and the young man went home, dragging his feet with every step.

A young girl, about 11 years old, came to get the family mail. Realizing that she had the wrong key, she gently laughed at herself, faked an angry stomp of her foot, and walked back to her home. She came back moments later to happily retrieve the mail. I wondered if she would be part of my science program. I hoped that she would be. The atmosphere at Coleson Village made me think about how pleased I was to be given this opportunity, how anxious I was about what I was to learn, and how nervous I became about how I would pull it all off.

Ethel, the family support coordinator for Coleson Village, finally arrived and our meeting began. I liked Ethel right away. She was energetic, funny, and obviously loved the girls. She was interested in providing them with quality activities to fill their days and evenings. We set dates for the program, she gave me a tour around the commons building, and we parted ways with a handshake. Before I left, she said to me, "I can tell, we're going to have some fun together." and I knew we would.

I drove home with the reality of my situation weighing heavy on my mind. I was now in charge of planning a program and an 8-week curriculum, gathering materials, organizing mentors, collecting data, keeping accurate notes, putting together a science fair, and, most importantly, encouraging a group of young women in science.

Supplies

It was now time to focus on getting the curriculum and the supplies ready for the program. Since the program and curriculum had been planned prior to meeting with the

YWCA, I was able to finalize a few details and create a supply list. The YWCA generously donated some of the items on my list and I spent the next Saturday shopping for additional items like miniature aluminum pie pans, Q-tips, laundry starch, plastic eggs (thank goodness it was near Easter), 9" balloons, Silly Putty™, and journals for the girls and mentors to write in. It truly was an adventure—shopping for my own project, something that I designed myself and that would hopefully have an impact on the girls who participated.

Mentors

The next step was to secure mentors for the program. Having mentors in the area of science appears to be important in encouraging girls to pursue science. Many studies have found that having informal sessions with women who work in science can change girls' views that people who are good in science are 'nerdy' (Campbell, 1992, p. 6). However, the YWCA had told me that they ran a mentorship program previously, with college-aged mentors, and that it was not very successful. They had problems getting the mentors to commit to the 8-week session and to come every week. I was a little worried about this. My contact at the YWCA suggested that using high-school aged mentors may prove to be more successful.

I decided to recruit high school and college-aged mentors. I immediately contacted the advisor for SWIMS (Society for Women in Math and Science), at a local university. As an alumna of this particular university, I was excited about contacting the science department again. The SWIMS advisor was extremely helpful and excited about

the project. She wanted to offer the women in science at the university a chance to participate in the surrounding community. She sent an e-mail out to 80 members of the women's group and received 12 inquiries back. Five of these young women committed to the program. In addition, I recruited two young women the high school where I was teaching at the time. They were both excited to work with young girls during this science enrichment program.

We would begin the program with seven committed and excited mentors. I was thrilled and absolutely terrified at the same time. I have supervised student staff before, but I have never coordinated and nurtured volunteers. Volunteers are a special breed of people who deserve constant gratitude and support, and I hoped that I was up to the challenge of providing both on a continual basis, and in the midst of attending to the details of my project.

The Beginning

The Saturday kick-off came on March 11, 2000, and we all gathered at the Coleson Village commons building. I met the girls and we talked about school. The mentors slowly trickled in and we all introduced ourselves. We joked and played until we were ready to start. For the kick-off, exhibits were set-up which asked the questions we would try to answer throughout the course of the 8-week program. They slimed goo on each other, played Operation™, and determined whether eggs were raw or boiled. We talked about the program, my study, their prior science experiences, and what we wanted to learn. Upon my request, they all drew pictures of scientists and wrote a beginning entry in

their journals. When the two-hour kick-off event was over, we all said good-bye and promised to meet on the following Tuesday. The girls walked the mentors to the door and made sure they knew all of their names. The girls then helped me pack up my supplies.

Ethel bought ice cream for the event and the girls made ice cream cones. We sat together, had a cone, and talked about school, what they liked about everyday life, and boys. I liked them so much already and hoped again that this program would positively impact their feelings about science and about their own abilities. Destiny, one of the girls, said to me, "You're fun. I like you." I thanked her and returned the compliment. They giggled and we all said goodbye. I was elated on the drive home. We had begun our journey together.

Data Collection

The plan for data collection was carefully worked into the enrichment program schedule. I didn't want the girls to be overwhelmed with questionnaires, interviews, etc. because I wanted their focus to remain on the content of the program and working with their mentors. However, I needed to be sure to use every available opportunity to gather data and information.

Several types of data were collected over the course of the program. Documents, such as surveys and questionnaires; interviews; participant and direct observation; and physical artifacts were used. All data was verified using methods of triangulation and member checking. All participants and mentors were asked to sign a consent form prior to beginning the program. The participant and mentor consent forms are in Appendix B and

Appendix C, respectively. All names have been changed to protect the confidentiality of the participants.

Documents

The girls were asked to complete a couple of different questionnaires. First, they were asked to complete a pre- and post-survey designed by the YWCA of Tacoma-Pierce County. The pre-survey form is designed to access the girls' current feelings about math, science and technology. The post-survey form is the same as the pre-survey, except that it also asks directly if the Operation S.M.A.R.T. program helped them feel more confident and smarter about math and science. They completed the pre-survey on the first Tuesday of the program (March 14th), and the post-survey on the last evening of the program (April 2nd), prior to the science fair. Copies of the YWCA pre- and post-survey forms are reprinted with permission in Appendix D and E, respectively.

BECCS pre- and post-questionnaires were also created in order to support my own research questions. The girls were asked to complete these questionnaires at the same time they completed the YWCA survey forms. Copies of the BECCS pre- and post-program questionnaires are included in Appendix F and Appendix G, respectively.

In addition, the mentors were asked to complete a questionnaire that was also designed to help answer my research questions. The questionnaire is in Appendix H. Their answers to these questions were in turn used to formulate the questions asked during the mentor interviews, in order to allow them to further elaborate and clarify their ideas.

Interviews

Several interviews were conducted throughout the course of the program. On the first Tuesday (March 14th), I interviewed all the participants in a group focus interview. The mentors were not present. The interview lasted about 45 minutes and was tape-recorded. A copy of the interview questions can be found in Appendix I. The girls were very animated during the interview and a good deal of time was spent keeping them focused and reminding them to be polite while others talked. However, it was a good interview in which a great deal was learned about how the girls feel about science.

After interviewing the girls as a group, there was one young woman, Jessie, who I wanted to talk to further. She was a junior in high school and had been involved in MESA (Math, Engineering and Science Achievement). She had a lot to say about women in science. However, in a group interview, we did not have time for her to go deeper into some areas of discussion. I interviewed Jessie alone on April 12, 2000. The interview lasted approximately 30 minutes. The interview questions are located in Appendix J.

All of the mentors were also interviewed. These interviews were conducted in small groups since it was nearly impossible to coordinate all of their schedules. A group of four mentors were interviewed on April 26, 2000, and the two high school mentors were interviewed on April 28, 2000. Both groups were asked the same questions (as seen in Appendix K) and both interviews took approximately 30 minutes.

Observations

Observations were gathered in two different ways—through participant and direct observation. As a participant in the learning process, there was a great deal to be observed.

Notes were taken as time allowed, but the bulk of my note taking was saved for the time after each session, when my observations were recorded in a journal. Since the mentors were so great in working with the girls and answering their questions, I was fortunate to be able to take some time each week for direct observation, sitting in a chair near the group, listening to their conversations, watching their faces, and taking notes. The observation protocol form is located in Appendix L.

In the beginning of the program, the mentors were asked to take note of the ways in which the girls interacted with the material and with each other. They were given a list of the types of things to look for (reprinted with permission in Appendix M), and a journal in which to write their observations. Their observations and notes were used to corroborate my own observations.

Physical Artifacts

There were several physical artifacts used to interpret what happened during the BECCS program. At the first meeting, the kick-off gathering, the girls and the mentors were asked to draw a picture of a scientist doing whatever they think scientists do. I also asked my own biology classes (about 100 students) to draw the same picture so that a possible comparison could be made between the girls' drawings and those of a different co-ed group.

In addition, the girls were asked to keep journals and write in them every week. The list of journal questions is located in Appendix N. The journals were collected midway through the program and their entries were photocopied. They were collected again at the end of the program. The girls were allowed to keep their journals, which made

them very happy. The mentors answered some of the same questions in their journals as well. I kept a journal in which I wrote everything I did, thought, and felt throughout the course of planning and implementing the program.

Finally, pictures were taken every week of the girls and mentors working on projects together. A signboard highlighting the pictures was created for the science fair. The science fair, which was the culminating event for the BECCS program, was videotaped. I have watched the tape several times, noting the pride on the girl's faces, as well as important interactions.

Over the 8-week period, everyone involved was interviewed, data was diligently collected, and many observations of the program participants and mentors were made. All of this information has been melded together to help tell the following story of the participant's experiences in and perceptions of science, and how they were affected by working with other women in science.

CHAPTER 4

The purpose for providing this enrichment program to young girls was twofold. One main purpose was to determine whether or not this type of program would have positive effects on girls' confidence level in science and whether or not the program would empower girls to participate more in science—giving them the beginnings of a solid 'prior experience' foundation. Another purpose was to determine if having mentors participate with the girls in science exploration would have a positive effect on girls' level of confidence in science. Learning how girls feel about science, how they formed their opinions, and how any negative feelings might be reversed was our overall purpose in participation in this enrichment program. In the end, the answers to these questions and answers to a few other questions were found, and new questions to be answered in later studies were formulated.

Effects of Enrichment Program

"Science is a fun thing when you do it step-by-step. When you rush and do it all at one time, you may not get it done." – Sophia, age 11

This enrichment program positively affected all participants. On the first day we all met together, one could sense that positive things were going to take place. The girls and the mentors were asked to draw a picture of a scientist. As we were busy drawing and coloring, an interesting thing happened—we immediately began to form relationships. We

spoke of schools (elementary, middle, and college), families, hobbies, and science. We laughed, teased each other slightly, and shared our pictures. Young women from age 8 to age 24 bonded and became new friends. We knew then that none of us would be the same after this program ran its course.

During the kick-off gathering, a weekly agenda for the program was discussed. We talked about the projects in which we would engage on a weekly basis. The agenda, on a large poster board, was then posted on a bulletin board in the commons building. Every week at the end of the session, the girls looked at the agenda to determine what we would be doing the following week. They would ask me questions about the planned activity and got very excited about several of the projects. This was a moving part of the evening. It reminded me what a wonderful thing this was for them and how these types of programs can really build confidence, self-concept, and excitement about science.

Prior Exposure to Operation S.M.A.R.T.

Five of the girls who participated in BECCS had previously participated in Operation S.M.A.R.T. through the YWCA of Tacoma-Pierce County. It was interesting to observe the girls *with* that prior experience compared to the girls who had not attended Operation S.M.A.R.T. previously. The prior experience showed itself in two different ways. First, many of the participants drew females when asked to draw a scientist. And while this may not seem unusual at first, my experience when asking kids to draw a scientist is that there are many pictures which resemble Albert Einstein in a lab coat, holding a test tube. (This was true of the drawings created by the 100 students in my sophomore biology classes.) However, many of the the girls at Coleson Village drew

female scientists who were involved in scientific study, but whose labs resembled comfortable rooms. They drew windows, pets and plants—a few even drew women working outside in the field. Some of the scientists had medium to long hair, and one even wore a dress and no lab coat. When they were done drawing their pictures, they presented them to the group. Sharay, the young girl who drew the woman in a dress (with spaghetti-straps) said, "My scientist looks like she is going on a date." It seemed that the girls' awareness, having had some prior experience, had already been raised to acknowledge the fact that there *are* women scientists and they often don't look like they are depicted in the media. It was okay with them to mix a 'feminine' image with science.

Second, it was evident that many of the girls had been to a previous Operation S.M.A.R.T. group because when interviewed as a group, several girls spoke about how subtle discrimination can take place in the science classroom. For example, one girl talked about how often in science classrooms the teachers tend to call on boys more often to answer questions. It was great to have a beginning awareness of issues that women face in science already in place because we could then build from there.

Although this prior experience is wonderful, giving girls much needed practice with science concepts in an environment of their own creation and raising their awareness of women's issues, one 8-week program is not equal to the years of prior experience with science concepts that so many boys get at home. This program is evidence that we need to continue to build girls' experience with science over time, because even though the girls who had previously participated in Operation S.M.A.R.T. were indeed 'smarter,' they still had many negative perceptions about science, and they continued to gain confidence and experience over this 8-week BECCS program.

Self-Concept and Self-Confidence

Many of the girls indicated that their levels of confidence in math and science increased after BECCS. One young girl, Faith, a 7th grader, showed many positive changes, not only in her comfort level with hands-on activities, but also in the way she feels about science. She claimed, "BECCS made me feel smarter in science."

Faith's timidity and hesitance was obvious during the first few weeks of the program. She waited for directions before touching anything. She asked many, many questions to clarify exactly what was to be done before proceeding. By the end of the 8-week session, she was designing her own volcano for the science fair, excitement absolutely ready to explode from within her. Faith was the only girl who decided to do a project that we had not already done during the BECCS session. She was so happy to be sharing some 'expertise' with her community.

Faith also showed growth as evidenced by the surveys and questionnaires she completed. One of the questions on the pre- and post-surveys was "compared with other subjects, how good are you at science?" Faith answered "about the same" prior to the program and "much more" after the program. Likewise, on statements such as "I think I could handle harder math" and " I like solving problems," Faith went from "not sure" and "disagree," respectively, to "agree" on both accounts. The most important thing Faith said she learned in BECCS was that "everything is science."

Sarita, one of the mentors, wrote: "Faith showed interest in the colors and in looking at the salt crystals under the microscope. She is independent, wanting to construct her crystal gardens herself." This supported my conclusion that Faith had grown during the

program to a point where she did not need to ask for directions every time she wanted to do something new. She had gained enough confidence to move through a lab on her own, at her own pace.

Another girl, Katelyn, seemed to go through similar changes. In response to the question, "compared with other subjects, how much do you like learning science?" Katelyn responded with "much less" in the pre-program survey and "about the same" in the post-program survey. Also, the question, "compared with other subjects, how *good* are you at science?" elicited a response of "about the same" on the pre-program survey and "much more" on the post-program survey. She grew to think of herself as a competent and successful scientist.

Sophia, a quiet girl who needed guidance quite often in the beginning of the program, and who did not seem to really like science, blossomed over the 8-week session into a young woman who was confident about her science fair project. When asked during the final weeks, "If science were a food, what would it be for you and why?" (Pollina, 1995), Sophia answered "Good ones. like rice, chicken, and pizzas..."

In their pre-program surveys, neither Faith, Katelyn, nor Sophia could describe a positive experience they have had in science. Faith and Sophia left the space blank underneath that question, and Katelyn actually described a negative experience. That was troubling to me when I read their surveys. However, words flowed on their post-program surveys. They all spoke of their excitement about the pending science fair and about how they loved to work with the mentors. Now they have a positive experience in science to tell about.

There was a strong need evident for the girls to claim time and space. Often, especially in the early weeks of the program, boys would stick their heads in the door to see what was going on. The girls would yell at the boys to "Go away. This is our program and it's just for girls." The first time this happened, we were engaged in the group interview and we were talking about the differences between girls and boys in the science classroom. A young man stuck his head in the door and said, "Is this still just for girls?" All the girls yelled, "Yes. Sorry. Bye." Then Jessie, an older and bolder member of the group said, "You'd think guys would be smarter. He sees all girls in here and he's going to ask if it's for girls only." The entire group laughed. You could sense their feeling of strength and their confidence because they could claim time and space as their own. My feeling is that this is not something they can easily do in their science classes at school, but they had the confidence to do it during *their* program and perhaps now this is something they can do when they need time and space at school

The girls' increased self-confidence and growth shone at the science fair, the culminating event for the program. The science fair was scheduled for 12:00 pm on Saturday, May 6th. The girls had spent their own time creating flyers and taking them door-to-door to invite family and friends. When the science fair was supposed to start, there were no parents or guardians in attendance. We waited for about 20 minutes. Finally, I decided that the mentors were there, all the other children from the community were there, and the girls were getting antsy to show their projects. We started the science fair, although the lack of family support was distracting for me. It seemed that these girls may be missing one key ingredient for success—family support.

My mom videotaped the fair and each girl introduced herself and her project on camera. They then described their projects and answered questions posed to them by other children. The girls were obviously proud of their accomplishments. We all clapped after each presentation. At the end of all the presentations, we had an informal ceremony during which the girls' accomplishments were acknowledged, they were given a certificate of accomplishment, a science fair award, a bookmark and a pencil. While they appreciated the gifts, they absolutely basked in the glow of support from the mentors, myself, and the other children from the community who attended. With the girls and the mentors glowing with pride, all the hard work put into facilitating this program seemed so worthwhile and worth doing again.

Effects of Mentor Program

Importance of Having a Role Model

It appears to be important to have quality role models in science, especially for girls, who look for relationship and connection. And while girls often see women as role models in science, it seems to be more important to have a role model with whom one can identify. In my own experiences, I did not have any role models (male or female) and I struggled in isolation. This was the major reason for providing mentors during the enrichment program. It was my desire for the girls to see high-quality, fun women who are pursing and loving science. The girls often spoke of the lack of women they see in science. Lisa, age 11, said, "I think if someone wants to be a scientist, then it's mostly boys. You don't see a lot of girl scientists." When the girls talked about scientists, they talked about popular science figures, such as Bill Nye the Science Guy, and the Crocodile Hunter.

During the group interview, the girls had some ideas about why there are not as many women as men in science:

> I think that boys are more interested and a little bit better at science and girls are just coming up in it because boys were allowed to do scientific stuff before girls were. Women weren't allowed to be doctors at one point and so guys have that advantage over us and that's why we are just moving up into the world and getting there and being able to show our interest and become a part of the scientific field.
>
> ~ Jessie, age 18

> I think that guys in my class are more interested in science because they are willing to touch slimy things, you know they are just more interested in it. Girls are like 'ew, that's nasty.' So, whenever we raise our hands, our teacher thinks that we're just going to say something stupid since we haven't been…touching the nasty stuff and she'll just choose the guys to demonstrate or something. She never chooses girls to demonstrate something, mostly guys. ~ Serena, age 11

However, having quality women role models in science helps girls see opportunities that are open to them in the field of science, and reminds them that they don't have to work in clerical career if they choose not to. After interviewing all of the girls in one large group, one young woman stood out—Jessie. Although Jessie is a resident at

Coleson Village, she was older than the program target group and had come to this program to help as a mentor. She was wonderful in that role since she had many years of rich science experiences.

I took the opportunity to interview Jessie individually since she seemed to have so much to share. Jessie had been involved with MESA (Math, Engineering, and Science Achievement) for many years. In talking about her experiences in MESA, Jessie and I spoke about the fact that the guest speakers for MESA's science groups have been mostly women. Jessie said, "I guess more females are willing to come and talk about their experiences because it's different for them. Guys have been in science ever since the atom was discovered and theories were made about it. It's not really a new thing to them. But for females, it's like 'oh wow, I can do this and you can, too.'" These speakers have helped Jessie see opportunities open to women in the field of science.

Enrichment and special science programs, like MESA, Operation S.M.A.R.T., and other community programs, provide girls access to women in science that the girls may have not had otherwise. All of the girls responded positively in their questionnaires about the BECCS mentors. Faith claimed that the mentors helped her better understand science because "If I asked one of them a question and didn't understand the way they put it, I could ask a different mentor and she would put it a different way."

The mentors helped the girls become more confident in science. Each week, the girls waited at the door of the community center for the mentors to arrive. When they finally drove up, the girls greeted them and pulled them to the tables where we met. The girls sought their mentors' approval, which the mentors willingly gave. The mentors challenged them with questions about science and how things work. The mentors

demonstrated to the girls that it is okay to like science. A person does not need to be a 'nerd' to enjoy science. One of the questions on the post-program survey asked why the girls chose to work with certain mentors. Katelyn stated that she chose her mentors because they were "cool and outlandish." One of the strong parts of this particular program was the strong connection with quality mentors.

The mentors were asked if they have female role models in science who have helped them along the way and given them encouragement. Many of them named a teacher, either from middle school, high school, or college. A couple of them mentioned parents (mothers and fathers) who are physicians or otherwise in a science-related field.

Maggie, a junior in college, had just found a female mentor and was quite happy about that. "I just met a female role model this semester. She is a professor who is doing a fellowship and she knows exactly what she wants to do. I keep thinking 'someday I could be like that.'" Meeting this professor seemed to give her some new direction and hope. She had mentioned earlier in the interview how sometimes she wondered what her life and a career in science would 'look like' for her.

All the mentors, successful women in science, have some type of female role model to look to for encouragement and guidance. At all ages, it seems to be a vital part of women's success in science—helping to keep us connected to each other and the content.

Connectedness

Everyone who participated in BECCS seemed to benefit from the closeness that was created. As mentioned previously, the girls religiously checked the posted agenda week after week to see what was coming up next. They constantly asked me if the mentors

would be coming the following weeks. They told me that they loved Tuesdays because they could come to BECCS after school. The girls were waiting at the door of the commons building when I drove up each Tuesday evening. They loved the group because they felt like they belonged to something important—and they did. They were part of a society of women scientists who came together to work on science-related projects.

Even the mentors talked about this connectedness when they answered my questions about why they volunteered and what they liked about coming to BECCS every week. Maggie said, "Yesterday I was kind-of stressed out and in a bad mood. Going to BECCS and making 'goo' with the girls made me feel better." Angelina claimed, "My favorite part of the program has been working with the girls. They are really sweet and so happy to have us there. I really enjoy spending time with them and they get so excited." "I like being able to contribute and help someone else out." added Camille.

The mentors volunteered because they were looking for 'connection' to the community, something they were not getting at their high school and college. They wanted a chance to encourage girls to pursue their dreams regardless of societal expectations and/or limitations. Most of the mentors approached me individually, either in person or via e-mail, to let me know that if there will be another program like this in the fall that they would love to be involved again. This sort of activity fills a need they have to connect community with content.

Connected Knowing

Biology as a Field of Study

It was intriguing to me that all of the mentors for my program were biology majors. Even the two high school women were planning science careers that involve a major in biology. This made me think of the books and articles I have read which claimed that women have begun to close the gender gap in life sciences, but not in other sciences (i.e. physics and chemistry). During my college years, male:female ratios seemed proportionate in biology classes, but females were definitely in the minority in chemistry and physics classes. This seemed like an important concept to explore with the mentors (since they are currently in college and closer to the source), and also briefly with the girls in order to raise their awareness of the issue.

The mentors had some interesting ideas about why females may consistently choose life science over other sciences.

"Physics and chemistry is more theory, like the theory of relativity. It's hard to see those things. It makes it more fun when you can actually touch and see whatever it is you're learning." – Andrea, age 18

"Whoever is actually good at these subjects is who gets interested. There are more guys who are better in math and physics." – Andrea, age 18

"I think of technology, physics, engineering—making stuff—as men things. Women prefer more emotional thing and interactions—more human interaction. I think there is more emphasis for females to be more social." ~ Maggie, age 20

"I think it's more socially acceptable for women to go into health sciences, taking the comforting, motherly type of work. It's more acceptable for women to become doctors and psychiatrists." ~ Maggie, age 20

"It might also stem from the traditional role of a woman as a nurse and that kind-of brought us into the field." ~ Sarita, age 18

"Not to be stereotypical or anything, but women are more into feelings and so biology might have something to do with 'what is this animal thinking, what is it experiencing, what is it feeling?' Something like that. I think that's why." ~ Jessie, age 17

These comments were interesting to me. There was a definite sense of separation of science topics for these young women. They spoke of physics, chemistry, engineering, math as 'other,' while relating feelings, relationship and human interaction to what women prefer. It caused me to reflect on my own experiences in science and why I chose biology as a major. Physics and chemistry always felt out of my reach intellectually. The 'aha' phenomenon never occurred for me in these sciences, but biology seemed to offer me a grasp on the content that the other sciences did not offer.

However, upon recent completion of a conceptual physics course , which was taught in a conceptual manner, using real-life relationships as the primary teaching tool and math as a secondary teaching tool, most major physical science concepts became clear to me. I was never so excited to understand anything before. These area of science need to be demystified so that females feel like they can participate and that it is not just a realm of unattainable knowledge.

Relationship to the Content

One thing that struck me right away about the ways in which the girls and the mentors talked about science is that they used rich, warm descriptions. When asked, 'what is science?' Sarita, age 18, answered, "Science is a means of understanding and discovering the world around us. It can be anything from a microscopic organism in the soil to the stars in the great sky above us." The girls and the mentors spoke about science not as abstract pieces and facts, but in a way in which each piece seemed to fit together to create a whole. They were asked many times to talk about what science is to them and how science fits into their everyday lives.

"Science is exploring. Discovering new and hopefully important information. Science is also applying this new information in helpful ways." – Kathy, age 22

"Science is necessary in our whole life. Science is something you'll do in your whole life." – Destiny, age 13

"In college, science sometimes doesn't seem applicable. But I always try to extend the concepts to apply to real-life." – Camille, age 20

"Science is the study of the elements and living things in the world around us and how they are interrelated to each other." – Angelina, age 21

"I think that science is nature, but it's everything that is man-made, too. It's how everything reacts with everything else and coincides with each other." – Jessie, 17

"Even when you're not studying science, you're learning it. When you take a walk and take in what's around you—the flowers, trees, even houses and housing developments. It all has something to do with science. You might not be consciously aware that you're experiencing it, but you're learning." – Jessie, age 17

The girls made several statements like this in the group interview. They seemed to have a clear picture of what science meant to them, but their meanings were not necessarily aligned with what they were taught about science in school. They indicated on several occasions that science is 'everywhere' and 'everything,' but they also claimed that in school it was just facts. One could sense their need for their relationship to science to be real and not just a list of memorized facts. The girls craved the hands-on, relevant experiences in science and were disappointed that, in many classes, the hours of reading, writing and completing worksheets far outweighed the hours of actually creating and experimenting. Jessie spoke eloquently about how she loved the science enrichment

programs, but did not love science class as much. "In science class, they want you to do a lot of reading without a lot of experimenting. You learn okay by reading, but you can only retain so much knowledge without actually experiencing it." she claimed. She had been through many science classes in which the teacher, for whatever reason, actually avoided lab work in favor of lecture and worksheets.

The girls seemed to really want a relationship to science, but they often found it difficult in science class since many of their classes taught only facts and no connections. Some of the college-aged women talked about creating these connections themselves, but possibly the younger girls are not yet cognitively ready to do this. It is our jobs as educators to make these important connections and give the science curriculum relevance for those students who require this for understanding. Science enrichment programs are successful at addressing this issue because they can be designed as single-sex programs, they generally have a low teacher-to-student ratio, and the participants are at liberty to play with science at their own pace, in an optimally prescribed learning environment.

Making Connections: Women's' Preference for Group Work

I was completely enthralled with the ways in which the girls and the mentors talked about how they prefer to work at science. One mentor claimed to like to work alone. She wrote, "I only like to work in groups if all the members are competent. I trust my own work most." However, all of the other mentors and the girls claimed to prefer practicing science in a group.

"I prefer to do science in a group. It's more fun to learn what others think and you have more ideas to throw around in a group" ~ Camille, age 20

"I like to practice science in a group because I believe that sharing ideas is an integral part of a scientific community." ~ Sarita, age 18

"Without a doubt, I prefer working in groups. In groups, everyone is able to contribute their expertise which allows everyone to learn more than they would alone." ~ Angelina, age 21

"I enjoy working in groups to gain perspective of others. There is a lot I can learn from other people." ~ Maggie, age 20

The mentors were asked several questions about why they think that group work is so important to them and why it helps them learn better. One reply was absolutely intriguing to me. Rachel, age 18, and Andrea, age 18, said, "If you read it in a book, you read it and it goes in and out. You thought about it for a minute, answered some questions and now you're done. If you're talking to someone about it, you'll remember those words; you'll remember what was going on. You'll remember what they were doing and the material will come to mind."

Part of the reason this answer interested me is because this is exactly how I remember important things. The fact is connected to what is happening around me and then the 'fact' is easier to recall when the entire situation comes to mind. The memory

comes as a whole piece, not as a single, discreet fact. This is quite interesting when we think about group work. When you work in a group, it is usually not the case that you sit around together and work independently. The group generally talks, laughs, and tell stories, sometimes even relating outside things to the content that is being studied. If women need this rich, stimulating environment in order to remember the minute details, then it makes sense that they would prefer group work. Group work often creates these stimulant-rich surroundings.

Informal Mentorship

In addition to group work, some of the girls talked about how key science teachers helped them make initial connections to science by giving them extra time and space to do science activities on their own. Several of the mentors talked about how their most influential science teachers were women who provided them with a connection to the content. Andrea said that her female role model in science was her 7th grade science teacher. She said that her teacher opened the room to them at lunch time so that she and other girls could come in and do 'science stuff.' She said that her teacher pushed them to understand and extend concepts. She also talked about her student/teacher relationship feeling close. "Maybe I felt closer to Ms. Collins because she was a woman, and always, no matter what, it's always a bit closer than with a male." Andrea said.

Jessie spoke of the same sort of 'informal mentorship.' She said that one science teacher who really influenced her allowed students to come into her classroom at lunchtime and practice science. These students were mostly girls. Jessie said that she always remembered this science teacher because she boosted her interest in science.

She also said that her favorite chemistry teacher always talked about careers and opportunities available to women and men in science. For example, they had one conversation about carpentry and cooking and their relationships to chemistry. Jessie's teacher began the discussion with questions like, "Where do you find chemistry in the workplace?" and "What jobs use this skill?" She would then ask the class, "Can a woman be a carpenter?" and "Can a man be a cook?" Jessie appreciated these conversations and attributed her openness to science and her awareness of jobs open to women in science to these conversations in the classroom.

Teachers often send messages to students without even realizing the messages they are sending. These teachers may or may not have an idea about the impact they have had on these young women, encouraging them in science just by offering their science room to them for thirty minutes. That is powerful. And just as often as girls receive the positive messages, they receive the negative. How many times have we given a male student more credit than a female student for a correct answer or a thoughtful response? We need to start looking at these issues for what they are and for how much they can impact our students.

Girls and Technology—Boys and Group Work

In the interviews, we briefly explored a couple of ideas about technology and their ideas about the ways in which males prefer to work. In the mentor interviews, they were asked how they feel about technology and the fact that researchers are now claiming that technology is the 'new boys club.' The young women recalled how the males they know tend to spend a lot of time on computers and video games, and how the mentors do not

understand how this is such an attractive activity to their male friends. They talked about how women in general do not like computers because they don't allow them to work together, since computer work is usually completed on an individual basis. Rachel, age 18, said, "Computers are interesting, but boys are more interested in them. I don't know why. Guys seem to like the isolated thing. Girls would rather talk to other girls or do thing with other people. They would rather interact with people instead of a machine."

One mentor, Camille, mentioned her thoughts on why males may prefer individual work. She spoke of societal pressure, which, in many cases, hits boys as hard as it hits girls. "Traditional guys are not supposed to need help with anything. They're supposed to do everything on their own. And in the group setting, the group interaction, even though you're all kind of contributing and helping each other out, it's one of those underlying things."

It was interesting to hear the girls and the mentors' thoughts about the ways they think that males prefer to work. They seemed to agree that boys like technology and computer work more than girls. None of them claimed to like working on computers, and they could all think of a male friend or two who could not tear himself away from the computer. They also seemed to have some firmly rooted opinions about males' preference for working alone.

Summary

Several things were learned in the course of my research. First, it requires great attention to detail and enormous amounts of energy to create a meaningful, fun enrichment program that might help young women increase their confidence levels in science. It is not

an easy task. It is important to have the creative steps in writing so that others may facilitate similar programs in order to encourage more girls in science.

Second, it became clear that enrichment programs do at least have some short-term, positive effects on everyone who participates. The girls, the mentors, and myself were all positively affected by this program. This was made clear in behaviors and in what the girls and the mentors said to me. It was absolutely apparent on the day of the science fair when they were glowing with pride.

Third, mentorship, in almost any form, is important for young women so that they can think about themselves as scientists. All of the girls and mentors had some form of mentorship—either through a mentor program, informal mentoring by a teacher, or just a parent who was in a science-related career who let them know they could do it too.

Fourth, this study confirmed the idea that females look for relationship in their work. They prefer content and methods that show them how concepts are connected to the whole picture. These young girls and women base their preferences on whether or not they can find relationship in the content.

Finally, we got a glimpse into how girls view their relationship to technology. Technology is another field that is growing rapidly and has enormous earning potential. If women are left out of this career field, then women are father away from gaining economic freedom.

When girls are offered an opportunity to participate in a group oriented, participatory science enrichment program, and given access to female mentors, then girls' attitudes about science change. The girls see and experience that science has a connection

to their lives. Science becomes a content area in which they can be successful and science careers are no longer strictly a male domain.

CHAPTER 5

"Women's exclusion matters, because of the power of science and technology in our culture: Exclusion from science thus means exclusion from power." (Barr and Birke, 1994, p. 473).

"I believe that the Feminine in each of us—the part of us that sees life in context, the interconnectedness of everything, and the consequences of our actions on future generations—can help heal the wounds of our planet." (Shepherd, 1993, p. 1)

Reflections

This study was important for me for several reasons. First, I have always doubted my own abilities as a strong and competent woman. In recent years, I have gained more confidence in my abilities, but it has come slowly. In rereading the journal I kept during this project, a couple of entries that struck me. When things had finally come together and we had dates for the program, I wrote, "I'm really happy, but also very nervous. My insecurities and doubts about being a smart, innovative woman are surfacing. I've done a lot of work and will do a lot more to make this successful, but I always doubt myself." Also, after I spoke to the SWIMS advisor about recruiting mentors, I wrote in my journal, "I heard myself talking on the phone and it didn't sound like me. I sounded smart and competent and I still have a hard time viewing myself this way."

As I read back through my journal and absorbed these entries, it was apparent how much I have grown in just this short year. This project was as much a journey for me as it was for the girls and the mentors. I undertook this level of commitment for my thesis program to help young women avoid the dangerous pitfall of self-loathing that happens so often for women in a white-male dominated society, and something found on the journey was an appreciation for my own abilities and strength.

The second reason this study was so important was because it made a difference for a group of young girls and mentors. On the day of the science fair, even though parents did not show up for their big day, the girls still were so proud of themselves. It seemed to be enough to them that *we* were there. They presented their findings to the neighborhood kids who were in awe of their projects. They got to shine for a few minutes that day and they felt valued. For eight weeks, they were the center of attention for seven female science mentors and me. *They* were the reason we all came together.

The mentors, too, grew from participating with the girls. Most of the mentors told me that if we do another program in the fall that they would love to be involved again. Many of the mentors asked me to keep in touch and told me that they would e-mail me over the summer. They had developed a connection with the community and they wanted to keep that connection.

The third reason this study was important is because we always need to illuminate ways in which we could be better educators. This study helped to determine some practical classroom methods that would allow us to approach science in a different way that would include the female perspective while not precluding the male perspective.

In her book about Barbara McClintock, *A Feeling for the Organism*, Evelyn Fox Keller (1983) reminds us of Ms. McClintock's approach to science. "Her answer is simple. Over and over again, she tells us one must have the time to look, the patience to 'hear what the material has to say to you,' the openness to 'let it come to you.' Above all, one must have 'a feeling for the organism.'" (p. 198). As educators, we must remember this as we approach the important job of educating all children in ways that are meaningful for them.

Future Study

There are several ideas for future study that stem from this study. It would be very interesting to me to do a longitudinal study in which we follow these girls through middle school and high school and into their undergraduate work to see if their interest and new found confidence in science persists. My guess is that for some of the girls, this program was a catalyst for change. It provided a new way for them to see science and to see how their lives relate to science. It may have been enough to push them to take the necessary risks in their science classes, to excel and get the attention of a teacher who will push them to new levels of competency and who will open their rooms at lunch time to welcome scientific work that takes place at a different pace than what happens in a classroom.

It would also be interesting to explore the link between women's preference for group work and the ways in which the female brain works. This may take some time since researchers often report conflicting theories about how the male and female brain differ, but it would provide insight into how educational practices may need to change to facilitate maximum learning for both sexes.

A similar study with boys would be an interesting comparison. It was difficult for me to not allow the neighborhood boys into the group. A couple of them asked if they could join and, while I told them they could not join this program, I assured them that I would talk to Ethel about offering a similar program for them. It was a difficult decision for me to make, since most kids can benefit from extra time and quality community programs. However, my program and presenting it in the way it was intended was my primary focus.

Finally, it would be interesting to explore the critical factors which cause a girl to view a woman, or a man, as a mentor or role-model. Some of the girls who talked about not having a role model in science actually had some female science teachers. For some reason, however, they did not identify them as role models in science. It would be educational to learn more about why girls would view one female science teacher as a role model, but not another.

Ripples in the Water

I received an e-mail from one of the mentors this summer. She and her Mom were going to conduct a small science program for some kids in her area and she wanted to have some of the 'recipes' used for our program at Coleson Village. After responding to her, I thought about how much impact one person, one program could make in the lives of others. We never really know whom we will touch through our efforts and how we will affect them. It reminded me of the ripples that grow into ever-larger circles when we drop a pebble into the water. We start small and hopefully the larger circles continue to grow. Long after this particular project has been put to rest, the effects of caring and of building

relationships will continue. We may never fully know the impact of this program on those 8 beautiful girls who lived at Coleson Village, but one thing we do know is that they will always have a story to tell about a positive experience they have had in science, and they will always have strong women in science to call role models. We couldn't really ask for more than that.

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